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# Débridement and Closed Packing for the Treatment of Necrotizing Pancreatitis

Carlos Fernández-del Castillo, MD, David W. Rattner, MD, Martin A. Makary, MD, MPH, Amy Mostafavi, MD, Deborah McGrath, RN, and Andrew L. Warshaw, MD

*From the Department of Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts*

**Objective**
To evaluate the results of débridement and closed packing for necrotizing pancreatitis and to determine the optimal timing of surgical intervention based on patient outcomes.

**Methods**
Between February 1990 and November 1996, 64 consecutive patients with necrotizing pancreatitis were treated with necrosectomy followed by closed packing of the cavity with stuffed Penrose and closed suction drains. The mean APACHE II score immediately before surgery was 9, and 31% of the patients had organ failure. Patients were stratified with an outcome score based on death and major complications; this was correlated with the timing of surgical intervention. The data were then subjected to cut-point analysis by sequential group comparison.

**Results**
Patients underwent surgery a median of 31 days after diagnosis. Fifty-six percent had infected necrosis. The mortality rate was 6.2% and was no different in infected or sterile necrosis. Eleven patients required a second surgical procedure and 13 required percutaneous drainage; a single surgical procedure sufficed in 69%. Enteric fistulae occurred in 16% of patients. The mean hospital stay after surgery was 41 days, and the interval until return to regular activities was 147 days. A significant negative correlation between duration of pancreatitis and outcome scores was found, and sequential group comparison demonstrated that the change point at which significantly better outcomes were encountered was day 27.

**Conclusion**
Débridement of pancreatic necrosis followed by closed packing and drainage is accomplished with a low mortality rate and reduced rates of complications and second surgical procedures. Although intervention is best deferred until the demarcation of necrosis is complete, delay beyond the fourth week confers no additional advantage.

The indications, timing, and technique of débridement of necrotic tissue in severe pancreatitis continue to be controversial. Agreement on operational clinical terms,[1] widespread availability of contrast-enhanced computed tomography (CT),[2] and the use of percutaneous needle aspiration to determine the presence of infection in pancreatic necrosis[3] have all contributed to a better understanding of the natural history of necrotizing pancreatitis and to improvements in patient care, but there is not yet a consensus regarding management.

This study describes our recent experience with the surgical treatment of necrotizing pancreatitis using a uniform technique of débridement followed by closed packing and drainage. Our outcomes demonstrate a marked increase in patient survival and a reduction in complications.

## METHODS

Hospital and office charts of 64 consecutive patients with necrotizing pancreatitis requiring surgical intervention between February 1990 and November 1996 were reviewed. Data on the etiology and severity of pancreatitis and the indications and timing of surgery were recorded. The following postsurgical outcomes were evaluated: bacteriology of necrosis, need for a second surgical procedure, subsequent percutaneous drainage, enteric and pancreatic fistulae, other surgical complications, need for intensive care and parenteral nutrition, death in hospital, hospital stay, interval

Address reprint requests to Carlos Fernández-del Castillo, MD, Massachusetts General Hospital, ACC/464, Boston, MA 02114.
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**Table 1. ETIOLOGY OF PANCREATITIS IN 64 PATIENTS WITH NECROTIZING PANCREATITIS REQUIRING DEBRIDEMENT**

| Etiology | Number | (%) |
|---|---|---|
| Gallstones | 28 | (44) |
| Ethanol | 11 | (17) |
| Idiopathic | 11 | (17) |
| PostERCP | 5 | (8) |
| Postoperative | 3 | – |
| Pancreatic cancer | 3 | – |
| Hyperlipidemia | 2 | – |
| Pancreas divisum | 1 | – |

ERCP = endoscopic retrograde cholangiopancreatography.

until return to regular activities, and development of endocrine and exocrine insufficiency. Follow-up after hospital discharge, obtained from office records and by telephone interview, was completed in 94% of patients.

To enable correlation among the duration of pancreatitis, APACHE II scores, and surgical outcomes, an outcome score was created by assigning points as follows: death, 5 points; need for intensive care after surgery, 1 point per week to a maximum of 3 points; need for a second surgical procedure or percutaneous drainage after surgery, 1 point each; and development of enteral fistulae, acute renal failure, pulmonary embolism, or acute respiratory distress syndrome, 1 point each.

## Patient Characteristics

There were 43 men and 21 women, with a mean age of 53 years (range 30 to 81 years). The etiology of pancreatitis is listed in Table 1. Fourteen patients (22%) had had previous pancreatitis, and 45 (70%) were transferred from an outside hospital.

The median interval between onset of pancreatitis and débridement was 31 days (mean 56 days). The mean and median APACHE II score of the 64 patients was 9 (range 0 to 23). These scores represent the state of the patients 24 hours before surgery; APACHE II scores at the time of maximum severity of the pancreatitis were not available because of the large proportion of patients transferred from other institutions. Twenty patients (31%) had organ failure at the time of surgery—12 in 1 organ, 3 in 2 organs, and 5 in 3 or more organs. Twenty-two of the 64 patients (34%) received antibiotics for 1 week or more before surgery, and 11 of the 64 (17%) had undergone prior percutaneous catheter drainage.

## Surgical Technique

A recent CT scan, preferably with oral and intravenous contrast, is desirable to guide surgical exploration by ensuring that all areas with necrosis or fluid are recognized and sought. We prefer a midline abdominal incision. The lesser sac can be approached through the gastrohepatic omentum, the gastrocolic omentum, or the transverse mesocolon. Because the stomach and the transverse colon are intimately and dangerously bound into the inflammatory process, we have found that entering the lesser sac through the mesocolon is often the quickest, easiest, and safest route to the target area (Fig. 1). Commonly there is thinning of the mesocolon to the left of the ligament of Treitz, and this avascular area is an ideal site to enter the space containing the necrotic tissues and fluid. The entry site in the mesocolon also allows drains to be placed in a more dependent position once the débridement is completed. Not infrequently, the middle colic vessels are thrombosed; if that is not the case, they can be interrupted without untoward consequences.

Fluid collected from the necrotic region should be sent for aerobic and anaerobic culture. Peripancreatic necrotic tissues are then removed bluntly, extending the dissection cephalad and laterally. The underlying body and tail of the pancreas are usually of firmer consistency than the peripancreatic tissue, but if a contrast-enhanced CT scan indicates that they are mostly necrotic, they must be débrided. This dissection is also done bluntly, clamping and tying any stringlike or firm attachments, but staying, if possible, out of viable tissues. Bleeding from the cavity walls may be from granulation or from significant vascular structures. Hemostasis can be difficult and may require packing of the cavity. In severe pancreatitis, it is not uncommon to have thrombosis of the splenic vessels; however, the spleen should not be removed unless it is obviously necrotic. A sample of pancreatic or peripancreatic necrosis should also be submitted for bacteriologic analysis.

The head of the pancreas cannot always be completely reached from the left-sided approach. If the CT scan shows

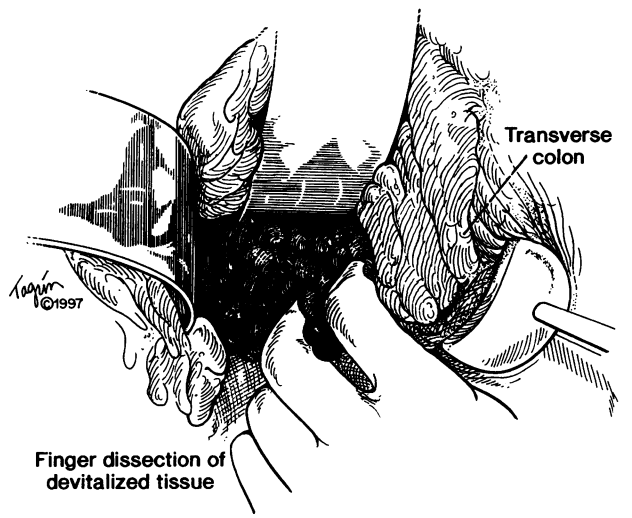


**Figure 1.** Blunt débridement of the lesser sac through the transverse mesocolon.

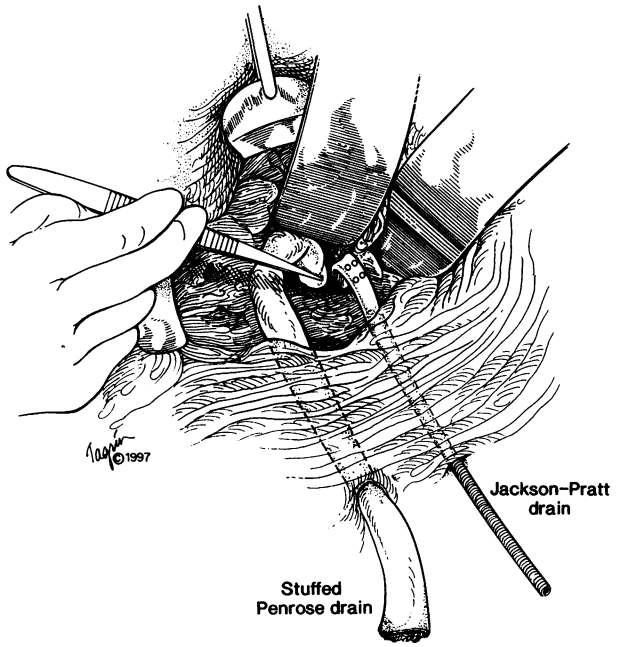


**Figure 2.** Packing of the cavity with stuffed Penrose and Jackson-Pratt drains.

significant necrosis in this area, it can be reached through the right side of the transverse mesocolon or via a plane posterior to the second and third portion of the duodenum. If fluid collections are present in the pararenal and retrocolic spaces, these should also be opened and drained. These collections can often be reached through the same transmesocolic approach used to drain the pancreatic bed, but there should be no hesitation to mobilize the hepatic or splenic flexures of the colon if needed for adequate exposure. Wider exposure of the primary cavity is easily obtained by dividing the gastrocolic omentum; insertion of the surgeon's hand through the mesocolon into the cavity provides a safe guide to the plane between the stomach and colon.

Because the thoroughness of the initial débridement is the most important factor in determining the need for subsequent reexplorations—and these in turn affect survival—every effort should be made to drain all fluid collections and to remove most of the necrotic tissue at the first surgical procedure. After blunt dissection, generous irrigation and gentle abrasion with the fingertips covered by a sponge provide further cleansing. However, too forceful or abrasive débridement can cause troublesome bleeding or injury to the bowel. The cavities resulting from the débridement are often stiff and may bleed from the raw surface. We pack these spaces with ¾″ Penrose drains stuffed with gauze, in addition to placing a soft silicone-rubber closed-suction drain in each major extension of the cavity. These drains are brought out through separate stab wounds and sutured to the skin (Fig. 2).

Six to 10 days after surgery, we begin removing the stuffed Penrose drains, one at a time, on sequential days, to allow the cavity to "collapse." The closed-suction drains are the last to be removed and are not withdrawn until their output is minimal. If a pancreatic fistula results, the drain tract is allowed to mature and then the drain is gradually advanced to allow the fistula to close behind it.

## Statistical Analysis

Unless otherwise specified, data are shown as mean ± standard deviation. Intergroup differences of continuous variables were compared using analysis of variance, and differences between proportions with the chi square test. Probability values less than 0.05 were considered significant.

Two-tailed Spearman's rho coefficients were calculated to assess the correlations among outcome score, duration of pancreatitis, and APACHE II scores. Nonparametric tests were used because the data demonstrated nonnormal distributions by the Shapiro Wilk test.

A scatter plot of outcome score and duration of pancreatitis was constructed. To demonstrate nonlinear trends, a line of best fit with 95% confidence intervals was determined using cubic regression. To identify the optimal time of surgical intervention based on trends in outcome score, a sequential grouping of patients by their duration of symptoms was performed such that sets of two-patient groups were compared by a Mann-Whitney test. This approach, also described as cut-point analysis,[4] allowed identification of the duration of pancreatitis at which a significant change in outcome score was observed. All statistical analyses were performed using SPSS version 7.0 (SPSS, Chicago, IL).

# RESULTS

## Indications for Surgery

The indications to proceed with surgical débridement and drainage were the following:

- Sepsis syndrome (16 patients [25%]). These are the sickest patients and are characterized by progressive deterioration beyond the first week with failure of one or more organs or systems, and often with leukocytosis and fever; 56% of them proved to be infected.
- Positive percutaneous aspiration (15 patients [23%]). A percutaneous fine-needle aspiration of pancreatic or peripancreatic necrosis was done 30 times in 25 patients, who, although not as sick as those with sepsis syndrome, either failed to improve or had equivocal signs of infection.
- Pancreatic abscess by x-ray (8 patients [12.5%]). This was diagnosed on the basis of gas in the pancreatic bed by CT; infection was confirmed in all cases (Fig. 3).
- Persistent pancreatitis (25 patients [39%]). These patients, after weathering the acute phase of the disease, failed to thrive because of persistent abdominal pain, low-grade fever, or inability to eat. Most of them underwent débridement beyond the seventh week. As

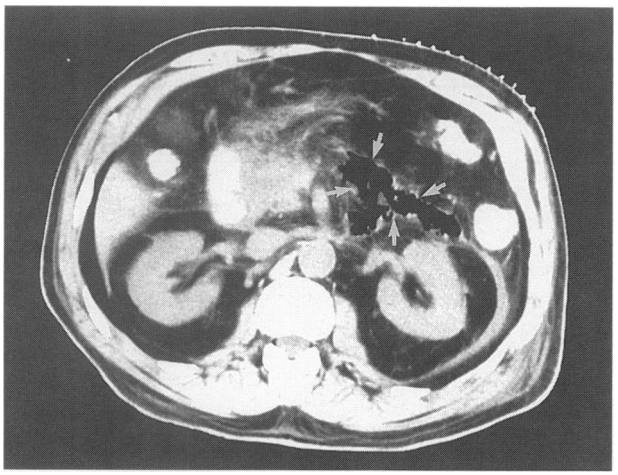

**Figure 3.** Computed tomography scan demonstrating gas within the pancreatic bed. Cultures grew a variety of aerobic and anaerobic bacteria, including *Clostridium perfringens.*

expected, their APACHE II scores as a group were lower than the rest of the patients, although 20% were found to be infected.

## Surgical Procedures

Mean surgical time was 167 minutes. Nineteen patients (30%) required blood transfusion (range 1 to 12 units) during surgery. In addition to débridement of necrosis and drainage, 20 patients underwent simultaneous cholecystectomy, 9 gastrostomy, 3 cholecystostomy or choledochostomy, 2 jejunostomy, 2 splenectomy, 3 colectomy, and 1 small bowel resection. The median number of drains employed for closed packing and drainage was 6 (range 2 to 14).

## Bacteriology of Necrosis

Cultures taken during surgery demonstrated infection of the pancreatic or peripancreatic necrosis in 36 of the 64 patients (56%). In 20 cases infection was by a single organism; in 16 it was polymicrobial. Table 2 lists the cultured organisms and their relative frequency.

## Mortality Rate

The mortality rate was 6.2% (4/64). Three of the patients who died were among those with the highest APACHE II scores (14, 21, and 22); death came 162, 2, and 90 days after surgery, respectively. The fourth patient survived a prolonged hospitalization for acute pancreatitis with organ failure, but was found to have gas within the pancreatic necrosis on a follow-up CT scan performed 4 months after the onset of her illness. Her APACHE II score before surgery was only 5, but after a semielective débridement she developed acute respiratory distress syndrome and died.

## Complications

After surgery, 29 patients were treated in the intensive care unit for a median of 6 days (range 1 to 44). Thirty-five did not require admission to the intensive care unit. Fifty-one (80%) required total parenteral nutrition for an average of 35 days. The first drain was removed on average on day 10, and the last on day 68.

Enteric fistulae developed in 10 patients (16%): 8 from the small bowel and 2 from the duodenum. Two of these occurred in patients who later died; all other fistulae closed without surgery. Thirty-four of the 64 patients (53%) developed a pancreatic fistula, but only 3 required surgical closure (several months after the initial surgical procedure); the rest closed with conservative management. The skin was closed in all patients, and 9 (14%) subsequently developed a wound infection (7 of the 9 had infected necrosis). A list of all complications is shown in Table 3.

## Subsequent Procedures

A second surgical procedure was required in 11 patients (17%), 2 for bleeding and 9 (14%) for persistent infected necrosis (1 patient required 3 débridements). Postsurgical percutaneous drainage of residual or recurrent collections was performed in 13 patients (20%, including 2 patients who required a second surgical procedure); 5 of them required more than 1 drainage. A single surgical procedure without further intervention was effective in 44 of the 64 patients (69%).

**Table 2. TYPE AND INCIDENCE OF MICROORGANISMS CULTURED FROM INFECTED NECROSIS IN 36 PATIENTS**

| | Number | Percent of Total Isolates (%) |
|---|---|---|
| Gram-positive cocci | | |
| *Enterococcus* spp | 12 | 18 |
| *S. aureus* | 12 | 18 |
| nonenteric *Streptococcus* | 7 | 10 |
| Gram-negative bacilli | | |
| *E. coli* | 9 | 13 |
| *Klebsiella* spp | 7 | 10 |
| *Enterobacter* | 4 | 6 |
| *Pseudomonas* spp | 2 | 3 |
| *Proteus* spp | 1 | – |
| *Citrobacter* | 1 | – |
| Anaerobic bacteria | | |
| *Clostridium* spp | 2 | 3 |
| Other | 1 | – |
| Other | | |
| *Candida* spp | 4 | 6 |
| *Lactobacillus* | 3 | 4 |
| *Hemophilus* spp | 2 | 3 |
| Total isolates | 67 | |

**Table 3. COMPLICATIONS AFTER DEBRIDEMENT AND CLOSED PACKING IN 64 PATIENTS WITH NECROTIZING PANCREATITIS**

| Complications | Number | (%) |
|---|---|---|
| Pancreatic fistula | 34 | (53) |
| Exocrine insufficiency | 16 | (25) |
| Enteric fistula* | 10 | (16) |
| Wound infection | 9 | (14) |
| Diabetes mellitus | 6 | (9) |
| ARDS | 3 | – |
| GI bleeding | 3 | – |
| Renal failure | 2 | – |
| Intraabdominal bleeding | 2 | – |
| Pneumonia | 1 | – |
| Biliary fistula | 1 | – |
| Pulmonary embolism | 1 | – |
| Wound dehiscence | 1 | – |
| Endocarditis | 1 | – |

ARDS = adult respiratory distress syndrome.
* Eight from jejunum; two from duodenum.

## Convalescence and Long-Term Sequelae

Diabetes mellitus developed in 6 patients (9%), exocrine insufficiency requiring enzymes in 16 (25%). The average hospital stay was 41 days, and the mean period of time before patients returned to their regular activities was 4.9 months.

## Early *Versus* Delayed Débridement

Patients who underwent surgery within the first 6 weeks of pancreatitis (n = 37; range 4 to 40 days, median 21) were compared with those who underwent surgery after 6 weeks (n = 27; range 52 to 300 days, median 75). Table 4 shows the indications for surgery, Table 5 their overall characteristics and outcomes. Although patients who underwent surgery within the first 6 weeks were significantly sicker and required more care in the intensive care unit after surgery, the mortality, reintervention, and complication rates were similar to those who underwent surgery later, as was the time until return to regular activities.

**Table 4. INDICATIONS FOR SURGERY IN EARLY *VS.* DELAYED DEBRIDEMENT**

| | Early* n = 37 (%) | Delayed† n = 27 (%) |
|---|---|---|
| Positive aspiration | 29.7 | 18.5 |
| Pancreatic abscess by x-ray | 10.8 | 11.1 |
| Sepsis syndrome | 35.1 | 11.1 |
| Persistent pancreatitis | 24 | 59.2 |

p = 0.03, chi-square test.
* < 6 weeks.
† > 6 weeks.

**Table 5. COMPARISON OF EARLY *VS.* DELAYED DEBRIDEMENT**

| | Early* n = 37 (%) | Delayed† n = 27 (%) | p |
|---|---|---|---|
| Apache II | 11.4 ± 6.3 | 5.7 ± 3.9 | <0.001 |
| Organ failure | 43 | 15 | <0.05 |
| Postop ICU | 65 | 19 | <0.01 |
| Postop TPN | 95 | 60 | <0.05 |
| Mortality | 8.1 | 3.7 | NS |
| Reoperation | 24 | 7.4 | NS |
| Postop percutaneous drainage | 22 | 18.5 | NS |
| Enteric fistula | 22 | 7.4 | NS |
| Pancreatic fistulae | 56 | 48 | NS |
| Other major complications | 35 | 19 | <0.01 |
| Postop hospital stay | 49 ± 33d | 30 ± 23 | <0.01 |
| Return to regular activities | 148 ± 89d | 147 ± 92d | NS |

ICU = intensive care unit; TPN = total parenteral nutrition; NS = not significant.
* < 6 weeks.
† > 6 weeks.

## Infected *Versus* Sterile Necrosis

Table 6 shows the characteristics of patients with infected necrosis compared with those with sterile necrosis. The stratification between early and delayed débridement was kept to make the comparisons more meaningful, because the proportion of sterile necrosis was higher in the delayed group. The only significant difference was a longer duration of pancreatitis in the delayed group (average 4.5 months) before proceeding with surgery in patients with sterile necrosis. This reflects a reluctance to perform surgery on patients with noninfected necrosis who are not acutely ill, although none of these patients had been able to return to their regular activities because of persistent symptoms and complications. There was no difference in the death rate or any other surgical outcome between patients with sterile and infected necrosis.

## Correlations Among Timing of Débridement, APACHE II Scores, and Surgical Outcomes

A significant negative correlation was observed between the duration of pancreatitis and outcome scores ($r = -0.39$, $p < 0.001$), and between the duration of pancreatitis and APACHE II scores ($r = -0.43$, $p < 0.001$). Similarly, APACHE II scores and outcome scores were found to be directly proportional ($r = 0.664$, $p < 0.0001$), indicating a

**Table 6. COMPARISON OF INFECTED *VS.* STERILE NECROSIS**

| | Early Debridement | | | Delayed Debridement | | |
|---|---|---|---|---|---|---|
| | Infected (n = 23) (%) | Sterile (n = 14) (%) | p | Infected (n = 13) (%) | Sterile (n = 14) (%) | p |
| Duration | 21.6 ± 9d | 21.1 ± 6d | NS | 74 ± 29d | 135 ± 74d | <0.01 |
| Apache II | 12.9 ± 6.5 | 8.8 ± 5.1 | NS | 6.6 ± 4.5 | 4.8 ± 3 | NS |
| Organ failure | 39 | 50 | NS | 31 | 0 | NS |
| Postop ICU | 74 | 50 | NS | 21 | 14 | NS |
| Preop antibiotics | 9.6 ± 8d | 8 ± 6d | NS | 32 ± 23d | 28 ± 22d | NS |
| Postop hospital stay | 54 ± 37d | 40 ± 24d | NS | 32 ± 23d | 28 ± 22d | NS |
| Return to regular activities | 141 ± 76d | 155 ± 103d | NS | 135 ± 64d | 158 ± 105d | NS |
| Mortality | 8.6 | 7.1 | NS | 7.6 | 0 | NS |
| Reoperation | 35 | 7.1 | NS | 0 | 14 | NS |
| Postop percutaneous drainage | 22 | 21 | NS | 38 | 14 | NS |
| Enteric fistulae | 30 | 7.1 | NS | 7.6 | 14 | NS |
| Pancreatic fistula | 52 | 64 | NS | 38 | 57 | NS |

NS = not significant; ICU = intensive care unit.

higher likelihood of death and complications in patients with higher APACHE II scores.

Figure 4 demonstrates the correlation between the duration of pancreatitis and outcome scores. The six patients with the longest interval between inception of pancreatitis and débridement are not depicted in the figure for reasons of clarity, although they are included in the calculations. The curve shows a significant difference in outcome score over time, with wide confidence intervals both at the beginning and at the end of the curve, indicating the variability in outcomes encountered in these periods.

Decision making as to the timing of surgical intervention should take into account the overall decreased risk (*i.e.*, better outcome score) over time, balanced against the costs (both economic and personal) and risks (higher unpredictability of outcome at the ends of the curve) of waiting. To gain further insight into this issue, we performed sequential group comparison. This analysis compares outcome scores at each time period (*i.e.*, the first patient against the remaining 63, the first 2 against the remaining 62, and so forth). It demonstrates significantly better outcomes from day 27 to day 80 (Fig. 5). Because no additional significant advantage is seen after the 27th day, further delay in proceeding with surgical intervention in symptomatic patients would seem unjustified, at least on the basis of the expectation of a better outcome.

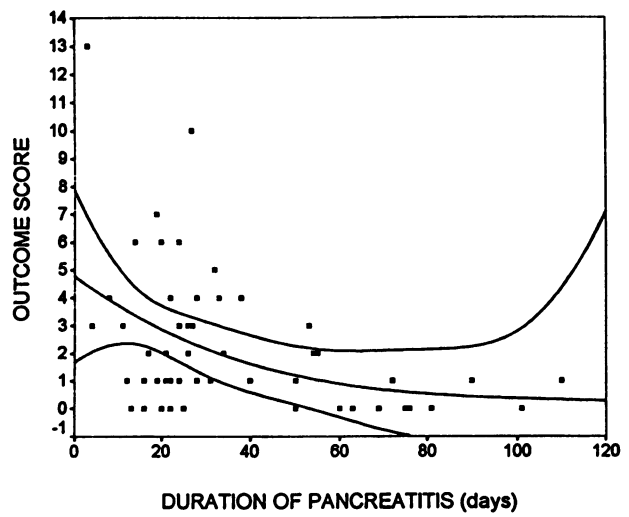


**Figure 4.** Scatter plot of outcome scores and duration of pancreatitis before débridement, with line of best fit and 95% confidence intervals. The six patients with the longest duration of pancreatitis are not depicted for clarity purposes, but are included in the calculation of the curve.

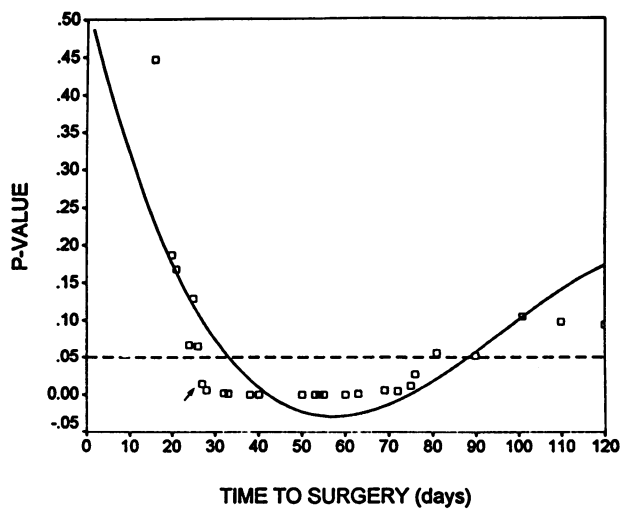


**Figure 5.** Probability values of sequential group comparison, with line of best fit. The first significant probability value (cut-point) is seen on day 27.

## DISCUSSION

This series of 64 patients demonstrates that débridement of pancreatic and peripancreatic necrosis, whether sterile or infected, can be done with a remarkably low mortality rate of 6.2%. The technique used—thorough blunt necrosectomy followed by closed packing of the resulting cavity with stuffed Penrose drains that are removed sequentially—made a single procedure sufficient in more than two thirds of the patients; only 17% of patients needed a second surgical procedure, and percutaneous drainage of residual or recurrent collections was needed after surgery in 20% of patients.

These results compare favorably to other recent series. Débridement followed by open packing with or without marsupialization of the lesser sac has been associated with mortality rates of 15% to 56%.[5–7] Staged necrosectomy by planned multiple procedures (with an average of 2.7 additional surgical procedures) has a reported mortality rate of 17%,[8] and a recently published series of necrosectomy followed by closure over drains had a mortality rate of 33%, with more than 40% of patients requiring a second surgical procedure.[6] Using yet another approach—necrosectomy with continuous lavage of the lesser sac—two large European series have reported mortality rates of 10.6% and 17.9%, with 27% and 17% of patients, respectively, requiring second surgical procedures.[9,10] Our reduced rate of either planned or unplanned multiple procedures translates into a reduced rate of complications and a lower cost of treatment.

The present results also represent an improvement over our previously reported institutional series (1985 to 1989) of 73 consecutive patients;[11] in that study, the mortality rate was 25%, and 46% of patients underwent a second procedure. Several factors may account for this change. In the older series, débridement was performed a median of 13 days earlier after the onset of pancreatitis than in the current series (18 *vs.* 31 days); consequently, the presurgical APACHE II scores were higher (10.9 *vs.* 9). In addition, patients in the earlier study were treated with a variety of surgical techniques, including open packing and closed drainage, whereas all patients in the current series were treated with the closed packing technique.

In the literature of necrotizing pancreatitis, there is ongoing debate as to the significance and proper management of sterile *versus* infected necrosis. We and others have shown that patients with sterile necrosis can be as acutely and even lethally ill as their infected counterparts.[11,12] Our clinical experience has shown that removal of sterile necrotic tissue can be a favorable turning point both in patients who are receiving intensive care with organ failure and in patients who are not critically ill but have persistent symptoms such as pain or inability to eat after an episode of acute pancreatitis.

Forty-four percent of the patients in this series had sterile necrosis. Half of them underwent surgery within the first 6 weeks (mean 21 days) and the rest after the seventh week (mean 135 days). Their inclusion in this series does not account for our better results, because internal comparison with patients who had infected necrosis showed no significant difference in their condition before surgery, mortality rates, or complication rates after surgery. It is also difficult to argue that these surgical procedures were unjustified. All patients in the delayed group had persistent symptoms that kept them ill and precluded them from returning to their normal diet and activities, but these patients had been denied surgery elsewhere on the premise that sterile necrosis would heal without invasive treatment. One of these patients had been in the hospital continuously for 140 days; another had been in and out of the hospital for 300 days before undergoing necrosectomy. Clearly, reabsorption of necrotic tissue and resolution of symptoms does not occur in all patients with extensive sterile necrosis, and the costs of delaying surgical intervention may be substantial.

In the sterile group that underwent débridement within the first 6 weeks, half (7 patients) had severe organ failure and were selected to undergo surgery on this basis. One of them eventually died, but the comparative outcomes of these patients were no different than those with infected necrosis. Although we have treated without surgery some patients with extensive sterile necrosis (not included in the present surgical series), these other patients do not constitute an appropriate control group because they did not ever have compelling indications to intervene (either organ failure in the early acute phase or interminable debilitating symptoms later). We cannot prove that surgical débridement was beneficial in this subgroup of patients with sterile necrosis and organ failure (*i.e.*, that they would have done worse if they had not undergone surgery), but our data do show that surgical intervention, if chosen, carries acceptable mortality and complication rates.

The bacteriology of patients with infected necrosis has changed over time. In the 1970s and early 1980s, gram-negative and anaerobic organisms predominated,[13] but today nonenteric gram-positive organisms are among the most common, representing 31% of all isolates in the present series. The change may relate to the widespread use of antibiotics given prophylactically or for nosocomial infections in patients with severe pancreatitis. Thirty-four percent of our patients had received 1 week or more of antibiotics before surgery. It is our current policy that all patients with necrotizing pancreatitis receive prophylaxis with either imipenem or a quinolone combined with metronidazole.

The timing of pancreatic débridement has also been a matter of controversy. Very early débridement (during the first week of the disease) has been associated with inordinately high mortality rates in several series.[14,15] In the single prospective clinical trial comparing early *versus* late débridement, the mortality rates were 56% and 27%, respectively.[7] Not only are the patients sicker earlier in the evolution of the injury (as shown by the negative correlation between the duration of pancreatitis and APACHE II scores), but the necrotic tissues are not well demarcated

from the viable. Thus, blunt necrosectomy is incomplete or impossible, and formal resections may be forced or substantial nonviable tissues must be left behind. Recognizing the practical issues and hoping for spontaneous resolution, most surgeons now try to wait longer, perhaps several weeks, before proceeding with necrosectomy. We compared patients who underwent débridement within 6 weeks of inception of pancreatitis with those who underwent surgery after this time. For reasons already stated, the indications differ between the two groups: persistent symptoms are the principal reason for performing surgery in the delayed group, whereas acute sepsis syndrome is the principal reason in the earlier group. Notwithstanding that patients were more acutely and severely ill in the first 6 weeks, the mortality and complication rates from the débridement were not different, nor was the hospital stay after surgery or the number of days from surgery to return to normal activity. The latter is an important consideration because unnecessary expectant observation, if frustrated in the end, incurs both higher hospital costs and loss of productive life.

We have analyzed our data to see if they indicate a window of opportunity during which outcomes are optimized and delay is minimized. Because there were only four deaths in the series, that parameter alone would have been inadequate for meaningful analysis. Therefore, we created a score incorporating several events that contribute to an adverse outcome. In our series, this score decreased significantly with the passage of time: the longer the interval between inception of pancreatitis and débridement, the lower the probability of adverse outcomes. Although the confidence intervals open widely at either end of the curve, indicating the variability of these time points, the cut-point analysis depicted in Figure 5 shows that by day 27 the outcome becomes significantly different (*i.e.*, better) and actually reaches its optimum, suggesting that delay in débridement beyond 4 weeks is unlikely to be of further benefit. Thus, although patients with infected necrosis should probably undergo surgery when infection is documented, in those with sterile necrosis delaying surgical intervention to the fourth week may be beneficial. By then, some patients will have recovered, and those who continue to be acutely ill or to have significant persistent symptoms will have a more complete débridement with less risk of complications from surgery.

Débridement for necrotizing pancreatitis is associated with significant postsurgical complications. The most common complication in this series was pancreatic fistula, occurring in 53% of patients. All these patients went home with drains in the surgical site and were managed conservatively with gradual drain advancement, sometimes with adjunctive octreotide. The average time until fistula closure was 86 days; only 3 patients required surgical closure of pancreaticocutaneous fistulae, 4, 7, and 8 months after the débridement.

Intestinal fistulae can be a major problem after pancreatic necrosectomy and, unlike pancreatic fistulae, may require in-hospital care. A small bowel fistula occurred in 10 patients (16%) in this series, including 2 of the 4 patients who eventually died. Others have reported incidences of 4% to 35%.[6,8,9,16–18] In some of those series, colonic fistulae account for the majority of bowel fistulae,[8,18] but there were none in our patients. It is possible that our preferred approach to the area of injury through the mesocolon, rather than through the gastrocolic omentum, reduces the chance of direct surgical injury to the colon and also keeps the drains from contact with the colonic wall.

Hemorrhage, often a major challenge in the management of necrotizing pancreatitis, can occur at the time of surgery or afterward. Although 30% of our patients required blood transfusion during surgery, major hemorrhage (one requiring 3 or more units of blood) occurred in only 6 patients (9%). Postsurgical hemorrhage occurred in only 2 patients (3%). Control of bleeding by angiographic embolization has been described for this situation,[19] but both of our patients required surgical reexploration. Other series have reported incidences of postsurgical hemorrhage of 20% to 26%.[6,8,18]

A prolonged hospital stay after surgery and a long convalescence are characteristic of this disease. The average hospital stay after surgery was 49 days for patients who underwent surgery within the first 6 weeks of pancreatitis and 30 days for those who underwent surgery after that time. However, the overall time required for patients to return to their regular activities (after surgery) was identical (148 days and 147 days, respectively). Much of the prolonged hospital stay is accounted for by inability to take adequate oral or enteral feedings and the need for prolonged parenteral nutrition (required by 80% of patients in this series). It has not been our practice to place jejunostomy feeding tubes at the time of débridement, but perhaps their more liberal use could reduce in-hospital stay.

This experience shows that débridement for necrotizing pancreatitis can be carried out safely. Our technique of thorough necrosectomy followed by closed packing and drainage of the débridement cavity has produced the lowest reported mortality rate, a low complication rate, and a need for a second surgical procedure in only 17% of patients. Our data also indicate that an inordinate delay is incurred in many patients who have significant amounts of necrosis and continue to be symptomatic, but who do not undergo surgery because they are not acutely ill or infected. Outcomes in these patients were no better or worse than those of patients who underwent surgery for sepsis syndrome, with or without actual infection. Although too early a surgical procedure (*i.e.*, within the first 3 weeks) should be avoided if possible, reluctance to proceed with débridement in patients symptomatic for more than 1 month cannot be justified on the basis of perceived high mortality or complication rates from the surgical procedure.

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